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THEORETICAL INVESTIGATION OF ATOMIC STRUCTURE AND SCATTERING PR--ETC(U)
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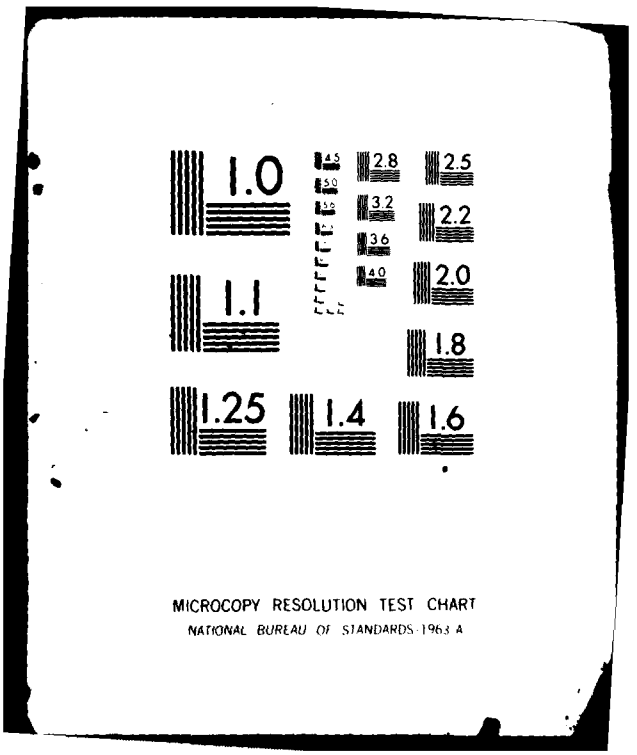
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18. SUPPLEMENTARY NOTES
Summary of research on theory of atomic scattering and atomic structure.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Scattering Theory — Atomic Structure
Free-Free transitions — Radiative corrections

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The theory of electron-atom scattering in a laser field has been studied and approximation methods applicable to low frequency laser fields have been developed. A study has been made of the dependence of the binding energy of heavy atoms on the atomic number. This is useful in developing generalizations to Thomas-Fermi theory.

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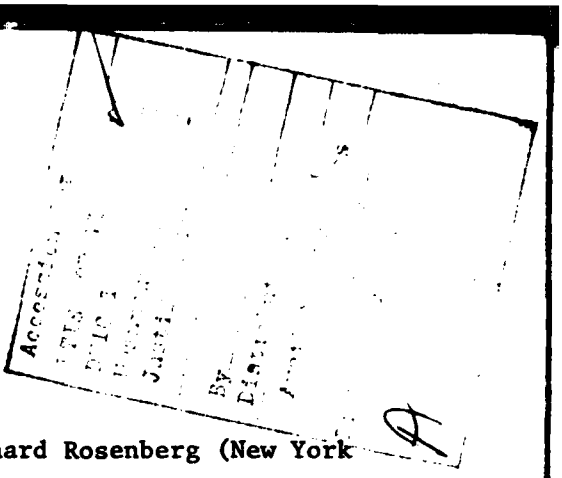

Summary

1. Principal Investigators: Larry Spruch and Leonard Rosenberg (New York University, Department of Physics, contract number N00014-76-C-0317).

2. Contract Description. The theory of scattering processes which take place in the presence of a laser field will be studied. We continue in our examination of the effects of long range forces on scattering parameters at low energies. The problem of determining radiative corrections to atomic binding energies will also be studied.

3. Scientific Problem.

To determine the transition rate for collisions taking place in an external field one must develop new calculational techniques in which, in addition to the interaction of the projectile with the target, one accounts for the interaction of the atomic system with the laser beam. Up to now very little work has been done on the important problem of electron-ion scattering in a laser field. We will study the effect of the long range Coulomb potential for the case where the laser field is of very low frequency. We hope to determine the way in which the long-range nature of the force affects the frequency dependence of the scattering amplitude.

We have previously determined how long-range polarization forces change the energy dependence of scattering parameters. By reversing the analysis we hope to use experimentally determined low-energy scattering cross

sections to determine the electric polarizability of elementary particles such as the neutron. We also wish to determine those long-range forces between atomic systems which arise from retardation and vacuum polarization effects using relatively simple, semi-classical methods.

4. Scientific and Technical Approach.

A proper treatment of the theory of scattering in a laser field requires that the laser field be represented as a finite pulse, rather than a monochromatic wave. Our approach involves the methods of time-dependent scattering theory for the formulation of the problem and variational methods for developing approximations. The merit of a variational calculation is that it allows one to make use of trial wave functions, determined, for example, from certain physical assumptions, to generate results of greatly improved accuracy.

5. Progress

As part of an ongoing study of the theory of electron-atom scattering in a laser field we have carried out an analysis of the range of applicability of various versions of the low-frequency approximation. Derivations were given which take into account the possibility of resonances. The same methods were used to derive the tunneling approximation for multiphoton ionization. An approximation for the amplitude for scattering in a constant crossed field has been derived. Divergences are avoided in this analysis by adopting a realistic model of the scattering process in which

the electron spends only a finite amount of time in the field. Use of the nonrelativistic Schrödinger equation as the dynamical model has been shown to be unnecessary in these derivations. Rather, only the general requirements of relativistic and gauge invariance need be invoked. Effects of the spin and anomalous magnetic moment of the projectile have also been included. A review article has been prepared on the subject of electron-atom scattering in a laser field.

A study has been made of the dependence of the binding energy of heavy atoms on the atomic number Z for very large values of Z. It was shown that the Z-dependence could be represented with great accuracy by means of a power series in $Z^{-1/3}$, retaining only three or four terms. The numerical values of the coefficients were shown to agree with theoretical estimates based on an analysis of corrections to the Thomas-Fermi theory.

A review article "A Unified Formulation of the Construction of Variational Principles", has been prepared.

6. Publications.

L. Rosenberg, Intermediate- and strong-coupling approximations for scattering in a laser field, Phys. Rev. A23, 2283 (1981).

L. Rosenberg, Scattering in a constant crossed field, Phys. Rev. A (to be published).

L. Rosenberg, Relativistic scattering in a slowly varying external field, J. Phys. A (to be published).

L. Rosenberg, Theory of electron-atom scattering in a radiation field, Advances in Atomic and Molecular Physics (to be published).

L. Spruch, Truncated expansion of the ground-state energy of a neutral atom in powers of $Z^{-1/3}$; coefficients of the leading terms (with R. Shakeshaft and J.B. Mann), J. Phys. B14, L121 (1981).

L. Spruch, Remarks on the existence and accuracy of the $Z^{-1/3}$ expansion of the nonrelativistic ground-state energy of a neutral atom (with R. Shakeshaft), Phys. Rev. A23, 2118 (1981).

R. Shakeshaft, Atomic collisions at asymptotically high impact velocities, in Proceedings of the XII International Conference on the Physics of Electron and Atomic Collisions, Gatlinberg, July, 1981, Invited Lecture (to be published).

7. Extenuating Circumstances.

None.

8. Yes.

9. None.

10. National Science Foundation.